Cold Start of the Power Plant Outlined in the Diagram

References:

Rollin M. Schahfer Generating Station starting Instructions by SimGenics
Steam and Gas Turbines by Skrotzki and Vopat
Boiler Operators Handbook by Ken Heselton
Combustion Engineering by Otto de Lorenzi, First Edition

We have electricity available from the grid so this is not a black start scenario.

Before getting into the specific step by step procedures, it is best to discuss what we are trying to achieve. The end result is that the generator will be interconnected to the electrical grid to supply electrical power. That is why we are attending to the turbine before starting the boiler. In general on all major equipment, we will follow these 3 steps:

1. Check oil levels, add as necessary.
2. Start cooling water to bearings and heat exchangers.
3. Start oil circulating pumps and check the oil pressure.

Pre-Boiler Starting Procedure:

1. Check oil level in turbine oil sump and generator hydrogen cooler sump, add as necessary.

2. Start and check the water inlet screens for debris from the river. Clean if necessary. Open air vents on water boxes of the condenser, check oil levels and start the main condenser cooling water pumps. Start the pump with the discharge valve closed and then it will electrically motorize the discharge valve open after the pump comes up to speed. Close air vents when water is running freely out the tops of the water boxes.

3. Start booster cooling water pumps to turbine oil cooler, and hydrogen oil cooler. Depending on oil temperatures, the cooling water may not be needed. A thermostat will determine whether cooling water or electric heaters are needed to keep the oil between 100 to 110 degrees Fahrenheit before starting.

4. Start auxiliary oil circulating pumps to the main turbine bearings (10-15 PSI), generator bearings, hydrogen oil seals and the turning gear.

5. Start the turning gear on the turbine rotor.

We are doing this first so that the turbine- generator rotor will not have any bowing by the time we are ready to start the turbine.

Boiler Start-up

6. Walk down the boiler from the top floor to the lowest level, make sure no personnel or tools and equipment are inside the boiler.

7. Close any doors to the furnace.

8. Make sure all manholes and handholes are closed and tightened.

9. Close all blowdown valves from the boiler.

10. Fill the troughs around the bottom plates of the boiler with water to provide a furnace air seal when the boiler expands. Fill the submerged scraper conveyor with water for bottom ash disposal.

11. Check oil levels on all auxiliary equipment:
- Main Turbine Lube Oil Reservoir
- Generator Hydrogen Oil Reservoir
- Station Air Compressors
- Induced Draft Fan Oil Reservoir
- Forced Draft Fan Oil Reservoir
- Air Preheater Oil Reservoir
- Condensate Pump Oil Reservoir
- Pulverizer Oil Reservoir
- Boiler Water Feed Pump Oil Reservoir

12. Check the auxiliary booster cooling water pumps that feed the:
- Main Condenser Vacuum Air Ejectors
- Generator Hydrogen Coolers
- Main Turbine Lube Oil Coolers
- Exciter Coolers
- The Tube Side of the Bearing Cooling Water Heat Exchanger
- Station Air Compressor Coolers
- Induced Draft Fan Oil Coolers
- Forced Draft Fan Oil Coolers
- Air Preheater Oil Coolers
- Condensate Pumps
- Pulverizer Oil Coolers
- Boiler Water Feed Pump Motor Coolers

13. The bearing cooling water heat exchanger has river water on one side and demineralized water or condensate on the other side to keep the water passages to the bearings clean.

14. Check oil levels and start station air compressors to supply pneumatic power to actuators and controls.

15. Check water level in the Deaerating tank. The demineralizers will add make-up water to keep the Deaerating tank at its normal level.

16. Open the drum vents, superheater vents, reheater vents, and other related boiler vents and drains.

17. Check oil levels in Boiler feed motor and pump bearings and start the pump to start filling the boiler. Stop when the water level is in the sightglass but below normal in the glass. The “swell” of the heated water will bring the water level into the normal range.

18. Open economizer recirculating valve to prevent steaming in the economizer during warm-up.

19. Open the main steam valve outlet from the boiler.

20. Check oil level, bearing cooling water flow, and start the Induced Draft Fan.

21. Check the oil level, bearing cooling water flow, and then start the Forced Draft Fan. The interlocks that permit starting the Forced Draft fan are:

I.D. fan running with discharge shut-off damper open
I.D. fan inlet vanes not closed
F.D. fan shut-off damper closed on the fan to be started
F.D. fan inlet vanes closed on the fan to be started
Oil pressure within limits
Oil temperature within limits
Low speed selected

22. Start the electrostatic precipitator

23. Set furnace pressure to -0.5”.

24. Check the gas train. Gas pressure should be around 35 psig. The two Maxon safety gas valves should be closed and the vent solenoid between the solenoid valves should be open. The two solenoids on the pilot valve line should be closed and the vent solenoid on the pilot line should be open.

25. Start the scanner fan. This blows clean air across the flame scanner so that it does not trip out from pulverized coal obscuring the lens.

26. Check the oil level and cooling water to the Ljungstrom air heater. Start the air heater.

27. The following conditions must be met before the gas burner will start:

No Boiler Trips Present
Forced Draft and Induced Draft Fans On
Boiler Drum Water Level within limits
Furnace Pressure Normal
All Gas Header Maxon Type Safety Valves Closed
All Gas Header Vents Open
All Coal Feeders Off
All Pulverizers Off
Ljungstrom Air Heater On
Air Flow > 30%
No Flame Detected
Burner Management Power Normal

28. Push the start button on the boiler control panel. The fans will go through a prepurge cycle that should blow 5 furnace volumes of air through the furnace before light-off. The fans will back down to a minimum fire position just prior to lightoff.

29. The ignitor will start sparking as the two solenoids in the pilot line open and the vent solenoid in the pilot line shuts. The pilot will light and the Fireye flame scanner must be satisfied for 10 seconds before the main valves will open. Check for a strong signal on the two U/V gauges on the control panel for that boiler, around 10 on the meter.

30. If satisfied, the two Maxon valves will open and the vent solenoid on the main gas line will shut. Main flame should be instantaneous. Check for a strong signal on the two U/V gauges on the breaker panel for that boiler, around 10 on the meter.

31. After the main flame is satisfied, the pilot solenoids will close and the pilot vent solenoid will open.

32. Check the gas flame pattern, it should be blue with yellow tips.

33. Slowly adjust the boiler master to warm up the boiler, around 100 degrees Fahrenheit per hour. Warming slowly allows all parts to expand equally.

34. Close the boiler drum vent when it is steaming at 25 psi.

35. Closing the boiler drum vent will allow maximum steam flow through the superheater. When the superheater drains appear to be blowing clear with no moisture present (a slight gap between the pipe and the cloud of water droplets) close down on the drain valves to increase flow through the whole superheater. Constantly observe the superheater outlet temperature. Close drains and vents except for the final superheater vent valve once you have the turbine rolling over. Close the superheater vent valves after the turbine is carrying a load. Confirm the reheater flow from and to the turbine before closing the reheater vent valve.

36. Watch the water level carefully and adjust manually. Blow down boiler if necessary. The correct procedure to blow down a boiler with two slow opening valves is to open the outer valve (furthest from the boiler) first. Open the valve closest to the boiler to blow down the boiler and then close the valve closest to the boiler and finally close the valve furthest from the boiler.

37. Blow down water column and gauge glass:

a. Hold the bypass button and open the blowdown valve for the water column. The alarm for the low water column should sound. It will then go off a few seconds after you have closed the blowdown valve. This will allow you to let the bypass button go without the danger of shutting down the boiler.

b. Close the chain valve for the bottom gauge glass. Open the gauge glass blowdown valve. This will blow down the steam line from the column through the glass. Open the chain valve for the bottom glass and close the chain valve for the top glass. Water will rush up to the top of the glass. Open the gauge glass blowdown valve and blow down the water end of the gauge glass. Close the gauge glass blowdown valve and open the chain valve to the top glass. Water in the glass should go back to the actual water level quickly.

38. Walk down the boiler and look for leaking handholes and manholes. If any are leaking, shut down the boiler, let it cool, and retighten or replace after draining.

39. Close the economizer recirculation valve when a steady feedwater flow has been established into the boiler.

40. Continue warming the boiler at no more than 100° Fahrenheit per hour while controlling the drum level until boiler pressure and temperature conditions permit turbine rolling. Once the turbine is rolled the first pulverizer can be started.

41. Put the feedwater regulator in automatic once steam flow has been established.

Starting the turbine

42. Verify that the main steam pressure is at least 500 psig with 100° F of superheat.

43. Start the gland seal steam condenser.

44. Establish the steam seals where the rotor extends from the casing.

45. Open all turbine cylinder casing drains.

46. Open gland leak off valve.

47. Drain condensate from main steam header and steam lines to the throttle valve.

48. Set condensate pump to automatically start when condensate is present.

49. Start the Single Stage vacuum jet air ejector (hogging jet):

    1. Open discharge valve to outside air.
    2. If a small condenser is provided with the hogging jet, turn on water supply valve.
    3. Open the steam valves, admitting steam from a supply line at the proper pressure.
    4. Open the air inlet valves.

    As soon as the full steam pressure is supplied in the steam chamber, the ejector will start operating. The vacuum will be gradually increased as the air is removed from the system and after a short interval of time the normal operating vacuum will be obtained.

50. Start the two stage ejector:

1. See that both steam valves are closed.
2. Open the air exhaust valve at the discharge of the second stage element or aftercondenser.
3. Open the air inlet valve at the inlet of the first stage air ejector.
4. Open the valve in the inter-condenser drain loop.
5. Open the drain valve in the after-condenser drain line.
6. Start water circulating through the intercondenser and aftercondenser.
7. Open the main steam supply valve, admitting steam at the proper pressure from the steam lines.
8. Open the steam valve to second stage air ejector. As soon as the full steam pressure is supplied to the steam nozzle, the ejector will start to operate.
9. Then open the steam valve to the first stage air ejector. After a short interval of time, the normal operating vacuum will be obtained.
10. Shut down the hogging jet.

51. Close cylinder drains to stages under vacuum.

52. Leave turbine cylinder casing drains open to stages not under vacuum.

53. With partial vacuum established 24" to 26" hg., quickly admit enough steam to start rotor spinning, then shut off.

54. Listen for rubs on the casing and at seal locations. If no rubs are evident admit enough steam to establish a rotor speed of about 200 R.P.M. Maintain about 1/2 hr to warm up casing and rotor evenly.

Start the Pulverizer

Now that the turbine is rolling, we can start the pulverizer:

55. Select the pulverizer control display. Verify that the gas gun ignition energy start permit is illuminated.

56. Select the start button for the pulverizer motor. Verify that the pulverizer starts as indicated by the pulverizer motor kilowatt increase. Verify that the pulverizer motor kilowatts drop back down after the initial starting current surge. Allow pulverizer to run for 5 to 10 minutes before starting the coal feed.

57. Select the open button for the hot air gate. Verify that the hot air damper travels to 100% open on the pulverizer graphic.

58. Select the start button for the coal feeder. Verify that the coal feeder starts as indicated by the feeder wattmeter Verify that the coal feeder controller output increases from 0% to 20%.

59. Verify that the pulverized coal main flame starts immediately and that the flame signals are stable.

60. Check main flame on control room TV monitor .

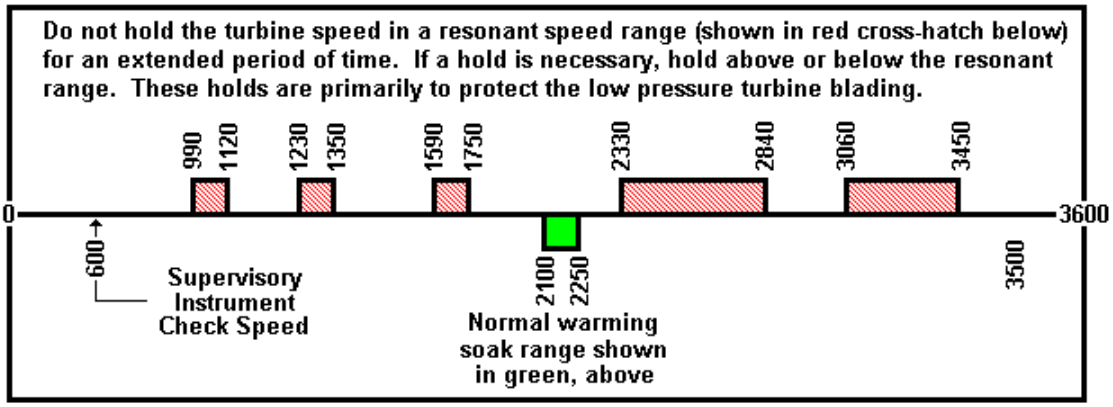
Back to the Turbine

There are two (2) categories of turbine starts. They are cold start and hot start.

A cold start is performed when either the turbine first-stage shell inner surface metal temperature is less than 250° F. A cold start is typically performed after the turbine has been shut down for one week or more. If a cold start is going to be performed, the turbine must be rolled to a reduced speed until the first-stage temperature reaches 250° F for a time period determined in the starting and loading charts.

A hot start is performed when the first-stage shell inner surface metal temperature is above 250° F. A hot start is typically performed when a unit is being started after a shutdown for less than one day. The turbine does not have a soak period prior to 3600 RPM.

This is a cold start procedure. There will be periods of time when the turbine will be held at a certain speed until rotor and casing are warmed evenly. The turbine should be sped through any RPM where the turbine manufacturer has determined there will be vibration (resonant speeds).



When the turbine reaches 2200 RPM, it must remain at this speed for the amount of time determined on the cold start warming procedure chart. For the purpose of this procedure, we will assume the turbine is completely cold and requires a minimum of three (3) hours at the rotor warming hold speed. NOTE: You should not start timing the three (3) hour hold until the hot reheat inlet temperature to the turbine reaches a minimum of 500° F.

61. Trip emergency hand control to make sure turbine shuts off.

62. Close throttle, reset trip, reestablish steam flow and slowly increase speed towards rated R.P.M. If rotor vibrates severely, decrease speed and continue warm-up until no objectionable speed occurs on speed increase.

63. Trip the governor by overspeeding the turbine to make sure overspeed trip is working.

64. Shut off steam throttle valve, reset the overspeed trip, reopen the throttle valve and bring unit back up to speed.

65. Close off the oil line supplying oil to the low oil pressure trip to trip turbine on low oil pressure.

66. Reopen the oil line. We shut off the steam throttle again, reset the overspeed trip and reopen the steam throttle. We have now tested the turbine trip by hand, by overspeeding, and by ensuring that a loss of hydraulic pressure will trip the turbine.

67. After the heat soak period, continue to open throttle valve until the turbine reaches rated speed and the governor takes over.

68. Make sure the governor takes over by watching the tachometer. If it does not show a speed increase upon continued opening of the throttle valve wider, then the governor has taken over. Also you will see the bar lift mechanism on the turbine start closing.

69. Adjust high and low pressure seals for operation (shut off sealing steam going to high pressure end. Leave on at low pressure end.)

70. Turn on water gland sealing water on the high pressure end, speed must be a minimum of 2000 rpm.

71. Close the cylinder casing drains that are not in a vacuum.

72. Check water to oil cooler to maintain an outlet oil temperature to the bearings of 110 degrees Fahrenheit.

73. At 3600 rpm but before synchronizing the turbine on the electrical bus, shut down the auxiliary oil pump by clicking the stop pushbuttons. The turbine should not trip because the rotor driven main oil pump should have taken over. If the turbine trips on low oil pressure, a serious problem exists and the turbine must be shut down for repair.

74. Synchronize by closing the electrical breaker onto the grid when the synchroscope is at 12:00 or at 5 minutes to 12:00 when the synchroscope is traveling slowly in the fast or clockwise direction. This to allow for the split second it takes for the large breaker contacts to actually close. Then by turning the speed adjuster knob we increase load on the turbine. The turbine is now locked on the grid and any increase in steam supplied to the turbine increases the K.W. output.

75. Open bleed line valves and put heaters into operation.

76. Bring unit up to share full load.

77. Shut down the gas burner.

78. Start the drag conveyor on the wet bottom ash handling system.